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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/649,099	08/26/2003	Woody K. Sattayapiwat Tang	M-12977 US	4957

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EXAMINER

DAHIMENE, MAHMOUD

ART UNIT	PAPER NUMBER
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1792

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PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/649,099	Applicant(s) TANG ET AL.	
	Examiner MAHMOUD DAHIMENE	Art Unit 1792	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 09 January 2008.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 3-18,27-35,37,40 and 41 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 3-18,27-35,37,40 and 41 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

3. Claims 3, 4, 7, 8, 9, 13, 14, 31, 32, 33, 34, 35, 37, 40, 41, are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083) in view of Doshita (US 2003/0235987) and Savas et al. (US 6,55,447).

The reference of Chen describes a method for via formation with reduced contact resistance wherein a structure is shown (figure 2B) to have a photoresist layer (210) on top an oxide layer (208)(which reads on applicant's limitation of an oxide based layer positioned on top (with an interface) of an ARC layer (206). Chen teaches "also formed

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during the oxide etching process is a coating of polymeric debris which is deposited on the floor of the via" (column 4, line 18). For example, where carbon tetrafluoride (CF_4) is used as the processing gas, SiO_2 is used as the oxide layer and (TiW) or (TiN) is used as the ARC, the polymeric debris formed in the via comprises polytetrafluoroethylene (C_2F_{2+n}) in addition to atoms of oxygen, silicon, titanium, and aluminum (column 1, lines 50-58) (which reads on the applicant's limitation of residues containing oxides and fluorides of titanium). Clearly Chen teaches residues will contain materials from layers that have been etched or contacted by the etching plasma in addition to byproducts of the gases used in the plasma for etching the layers. Chen further discloses A portion of the oxide layer is then removed to expose the underlying etch stop layer (ARC). A portion of the etch stop layer is then removed using a reactive ion etch-downstream microwave ash system (column 2, line 32), the reactive ion etch is performed under a nitrogen/hydrogen (N_2/H_2) atmosphere. In a more specific embodiment, the atmosphere further includes carbon tetrafluoride (CF_4) (which reads on applicant's limitation of a first agent which will react with the TiN ARC layer to produce volatile byproduct (column 2, line 45).

It is noted Chen is silent about Cl_2 , HCl or BCl_3 .

Doshita teaches residues containing tungsten nitride, fluorocarbon deposit and natural oxide are removed by using Cl_2 gas (paragraph 0025). Savas teaches "For instance, halogenated gases, such as SF_6 , **Cl_2** , CHF_3 , **CF_4** , C_2F_6 , CFC's, or the like, may be added to oxygen in small concentrations to

affect the chemistry of the reaction that strips the film off the wafer and **removes residue from the wafer.**"

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Chen to substitute chlorine gas or combine it with CF₄ because Doshita teaches Cl₂ gas is effective in removing residues containing tungsten nitride, fluorocarbon deposit and natural oxide and Savas teaches **Cl.sub.2** and **CF.sub.4** accomplish equivalent functions as far as residue removal is concerned. The substitution of one known element for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention, and is therefore held obvious.

It is noted that Chen is silent about the formation of residue nodules having a base anchor portion and top portion, however, it would appear that the oxide etch process of Chen would inherently result in exposure of nodules having a base anchor portion and top portion including nodule of different sizes because Chen discloses the same structure as the one claimed by the applicant of an oxide layer overlying a metal containing ARC layer and wherein the oxide has been patterned to expose the arc layer. The modified method of Chen removes those nodules by exposure to the N₂/H₂/CF₄ (Cl₂) plasma, this chemistry certainly reacts with a first metal element of the metal containing ARC layer (Ti) to produce volatile products, and the plasma molecules are sufficiently small in size to operatively enter reaction zones of the anchor portions of the nodules. In addition, applicant's claimed formation of nodules with base anchor

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portion reacting with the chemically reactive agent would obviously be produced upon practicing the modified process of Chen et al. (US 5,661,083).

As to claim 13, Doshita teaches "In contrast, when a silicon film is etched by using the mixed gas of a gas including chlorine and an inert gas, the amount of chlorine radicals generated in the plasma can be reduced due to dilution with the inert gas, and therefore, the etching is proceeded dominantly by a physical function of sputtering with inert gas ions." (paragraph 0056), And "n the case where the etching gas includes an inert gas, the inert gas can be a He gas, a Ne gas, an Ar gas, a Xe gas or a Kr gas." (paragraph 0057).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to further modify the process of Chen to include Ar with the chlorine because Ar is conventionally used as a diluents gas with Cl₂. One of ordinary skill in the art would have been motivated to dilute Cl₂ with Ar in order to effectively control the desired chemical versus sputtering removal rate as suggested by Doshita.

As to claim 14, Doshita teaches 0.4 Pa for the residue removal step (paragraph 0104). Overlapping ranges are held obvious.

Claim Rejections - 35 USC § 103

5. Claims 5 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083) in view of Doshita (US 2003/0235987) and Savas et al. (US 6,55,447) and further in view of Tang et al. (US 6156485).

The method of Chen as described above does disclose an oxide layer, but is silent about a specific oxide namely a PE-TEOS oxide.

Tang describes a metal etch method where a PE-oxide (140) or PE-TEOS (column 3, line 67) is used on top of a TiN ARC layer (130) (figure 3A).

Therefor it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Chen by including a PE-TEOS hard mask on top of a TiN ARC layer for a metal etch process because Tang teaches it is conventional to use those materials when etching an underlying metal layer, and the method of Chen can be used for a hardmask open step using the same process steps. One of ordinary skill in the art would have been motivated use Tang's method for hard mask in order to obtain an effective hard mask material.

Claim Rejections - 35 USC § 103

5. Claims 10-12, 15-18, 27-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083) in view of Doshita (US 2003/0235987) and Savas et al. (US 6,55,447) and further in view of S. Wolf et al. (Silicon Processing for the VLSI Era, Volume 1- Process Technology, Lattice Press, 1986, pages 546-547).

It is noted that the reference of Chen fails to disclose applicant's specially claimed flow rates and flow ratios and pressure.

Regarding claim 16, the reference of Chen discloses a plasma power in the range between 100-300 Watts (column 2, line 53). The disclosure of an endpoint of 300 Watts overlaps applicant's claimed range. Overlapping ranges are held to be obvious.

Regarding claim 17, Chen discloses a reactive ion etch at 13.65 MHz was performed at a power of 100 Watts (column 6, line 23) (which reads on a pedestal bias power) which is within the range of 80 to 200 Watts claimed by the applicant in claim 17. Overlapping ranges are held to be obvious.

Regarding claim 18, It is noted that the reference of Chen does not disclose applicant's specific cleaning time. However, cleaning time is related to the degree of removal. As a result, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select any amount of time necessary to achieve the desired level of removal, including the specific times claimed by the applicant, because the degree of cleaning is related to the amount of process time. Applicant has not shown anything unexpected with respect to the cleaning time.

The reference of Wolf et al. teaches that gas flow rates and pressure have a direct effect on the processed surface and are adjustable parameters (pages 546-547).

Therefore, in absence of unexpected results, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select any flow rate, flow ratio, power, frequency, and pressure that would accomplish the production of an effective plasma including the flow rates, flow ratios and pressure claimed by the

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applicant in claims 10-12, 15 and 27-29 because Wolf teaches it is conventional to select the proper gas flows in a plasma in order to achieve the desired results of a given processed surface. One of ordinary skill in the art would have been motivated to adjust the proper flow rates to the plasma in order to obtain the desired result.

Response to Arguments

Claim Rejections - 35 USC § 112 withdrawn

Rejection of claims 3-18 and 27-34, under 35 USC § 112 second paragraph is withdrawn in view of applicant's clarification of the terms "if any" and "relatively chemically nonreactive" in applicant's remarks of 1/9/2008.

Allowable Subject Matter withdrawn.

The allowable subject matter relative to claims 3-18, 27, 29, and 40 is withdrawn in view of the newly found references of Doshita (US 2003/0235987) and Savas et al. (US 6,55,447) which suggest chlorine containing plasmas are conventionally used for residue removal in semiconductor processing applications.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MAHMOUD DAHIMENE whose telephone number is (571)272-2410. The examiner can normally be reached on week days from 8:00 AM. to 5:00 PM..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

MD.

/Nadine G Norton/
Supervisory Patent Examiner, Art Unit 1792